Using Digital Sound in Marine Geoscience

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Introduction

Marine geoscientists are asked to provide a wide variety of information in support of activities off Canada's coasts, for application in many different fields. The data they collect can be used in support of environmental assessments and navigation, or to determine fish habitats and seabed minerals. Marine geoscientists need the best information they can obtain on seabed properties in order to design structures such as pipelines, wellheads and jetties.

One of the greatest challenges faced by the geophysicists is to collect seismic reflection (in this sense meaning "acoustic") and sonar sidescan data successfully in coastal waters. Because of the shallow water and the coarse nature of the seabed, capturing and processing the data to the desired quality has proven difficult with the old analogue systems. For this reason, scientists at the Atlantic Geoscience Centre of the Geological Survey of Canada (GSC)are turning to digital techniques to improve the results. A new program, called the "Marine Digital Initiative", is using digital techniques to collect, record, and process scanning data.

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What does "digital sound" mean?

Quite simply, it is a system of storing sound as a sequence of numbers corresponding to its frequency and amplitude. And since numbers are absolute, the advantage is that the sound is recorded very precisely, compared to the older systems. Think of the improvements brought about by using digital sound on compact discs. Formerly, when sound was recorded on tape, the quality when replayed depended on the dynamic range and band width - the quality of the tape. With digital recording, the characteristics of the original sound can be produced with no loss of quality.

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How does this apply to marine geophysics?

Marine geophysicists use sound as a way of creating an image of the seafloor and the sediments beneath it. Two main types of sensing system are used. For seafloor imaging, a sidescan sonar system is used, consisting of a towed "fish" that sends out a signal downwards and sideways. The sound is reflected by the seafloor, the echo is picked up by the "fish", and the system measures the volume of sound and its return time. Even irregular features on the seafloor, such as boulders or debris from sunken ships, will reflect some sound to the source. The information received can then be displayed as a sound image.

The second form of imaging is used to give a profile of the sediment beneath the seafloor. Some of the sound does not reflect immediately, but penetrates the seafloor. Sound may reflect from various sediment layers deeper down; the deeper it penetrates, the longer it takes to return to the surface. By measuring the time it takes for the sound to return, scientists can reconstruct a profile of the sediment column. Using the principle called "seismic reflection profiling", the ship moves along the sea surface continuously, repeating the process, until a cross-sectional profile of the seafloor sediments is produced.

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What are the advantages of using digital sound?

There are several. First, as with a stereo system, what is recorded is a much cleaner, more precise sound signal than can be obtained with the old analogue systems. Different textures reflect sound waves differently; the more accurately they can be measured, the greater is the precision of the resulting image. For example, digitized sound is capable of measuring the difference between fine and coarse sand on the seafloor.

The GSC scientists are even planning to digitize the sound directly in the towed "fish", to reduce the contamination of the signal over the long cables between the fish and ships. In the current system, contamination can occur from out side interference, or when amplified, interferes with a weaker signal from another channel. Once the signal is digitized, the risk of contamination is eliminated.

A second advantage is that the digitized sound is much easier to treat with modern processing techniques. On the old analog system, there was little that could be done to upgrade the quality of the sound over what was recorded in the field. It had to be played back on tape or cassette, and in the "real time". Advances in computers over the past 10 or 15 years have allowed for processing through a series of predetermined mathematical programs

(algorithms), and at higher speeds, to render the images clearer and easier to interpret.

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What about the recording equipment?

Obviously, as with a home stereo set, the electronic system used to record and play back the sound makes a difference to the end product. At the very low levels at which the digital sound is being recorded, the scientists need to know quite precisely the characteristics of the sound being set out at the start - the signal - if they are to interpret the returning sound correctly. For this reason, the systems have to be calibrated if the researchers are to derive quantitative information about the seafloor sediments. To do this, they have set up some very controlled experiments using all the components of the system in an experimental tank. The sound is then sent out and measured at various points in the system, using receivers with very precisely known response characteristics. The data are then incorporated into the program as fixed references. It takes quite a bit of effort, but it is worth it to be able to obtain quantitative data from the soundings.

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What is the importance of quantifying the data?

One of the reasons is our need to obtain information of the seabed sediments. We have to know their physical properties-strength, density, and degree of compaction. By using a calibrated system, we can potentially measure some of these properties indirectly, using the reflection characteristics and the calculated speed of sound through the sediment.

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How is the information handled?

One of the aims of the "Marine Digital Initiative" program is to reference all the data obtained to geographic coordinates. This will allow for the storage of the data in computer databses Occessible to a Geographic Information System. The flexibility in comparing the seismic and sidescan data with other information such as lithology (the structure and composition of rocks), sediment grain size and physical properties will be much greater.

And the Geographic Information System is also accessible by other government agencies and businesses interested working in Canada's coastal regions.

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Information

For further information on minerals, mining and geological research in Nova Scotia, please contact:

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Photos: (Not presently available)

Scientists at the Bedford Institute of Oceanography in Dartmouth use sophisticated acoustic system like the one pictured here for mapping the seafloor and its subsurface.

The Hudson is one of a fleet of research vessels at the Bedford Institute of Oceanography. The vessels are a primary tool for gathering geological data.

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Figures: (Not presently available)

Sidescan sonar data (below) reveal irregularities on the ocean floor such as scours caused by icebergs (top).

Sidescan sonar uses acoustic pulses that are reflected by the seafloor. Scientists use the data to distinguish irregular features and objects on the sea floor, as well as to distinguishing surface sediments such as sand or gravel.

The original seismic record (top) can be greatly enhanced using digital techniques.

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